# Simulations of Negative Curvature Hollow-core Fiber

J. Zhang[1], Z. Wang[1], J. Chen[1]

[1]College of Optoelectronic Science and Engineering, National University of Defense Technology, Changsha, Hunan, China

## Abstract

Hollow-core fiber is widely used in light-gas interaction, high-power laser transmission and ultrafast laser delivery. The negative curvature hollow-core fiber that is recently proposed has exhibited an unexpected low attenuation and controllable transmission bands in mid-infrared wavelength region. It has obtained intensive interests in high-power picosecond and nanosecond laser pulse delivery, micro-machining and minimally invasive surgery. Here, a finite element software, COMSOL Multiphysics® software, is used to simulate and analyze the transmission attenuation spectra of the negative curvature hollow-core fiber (See Figure 1). Using the mode analysis function of the RF module, confinement loss over the wavelength range from 2.7 μm to 4.2 μm was investigated. The effect of thickness of capillaries on confinement loss spectra was studied, as shown in Figure 2. Where we could obtain that the loss was smaller when the thickness was thinner, as well as that the high-loss and low-loss regions agreed well with the results predicted by the ARROW model, which verified the correctness of the physical model. In addition, the effect of the distance between the capillaries on the confinement loss spectra was analyzed, as shown in Figure 3, where we could find that the loss of non-touching capillaries was smaller than that of touching ones. Based on mode confinement factor, a criterion for selecting the fundamental mode was proposed. Theoretical analysis has shown that the integral coefficient of 0.5 could effectively distinguish fundamental modes from high-order ones (See Figure 4). This method was easy and accessible, and the error rate was fractional. This research could offer useful theory guidance for the design and fabrication of negative curvature hollow-core fiber, and laid a foundation for study of mid-infrared fiber-gas laser.

# Reference

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# Figures used in the abstract

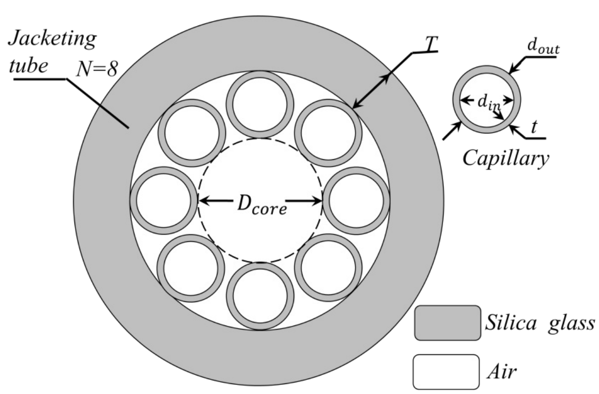


**Figure 1**: The cross-section of negative curvature hollow-core fiber.

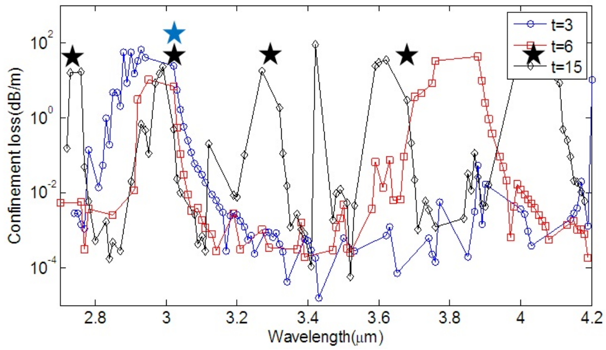


**Figure 2**: Confinement loss spectral with thickness of capillaries 3μm, 6μm and 15μm, respectively.

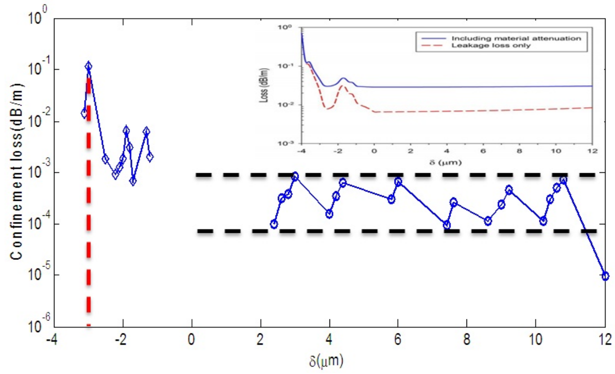


**Figure 3**: Confinement loss in touching and non-touching capillaries.

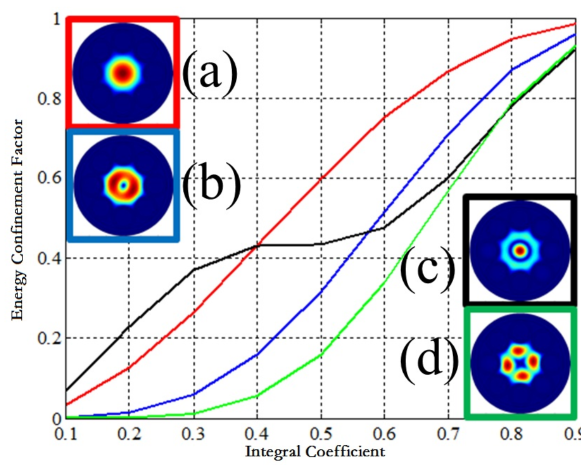


**Figure 4**: The energy confinement factor in four different modes with integral coefficient varying from 0.1 to 0.9.